Problem A

In class we derived

$$\left(\frac{\partial \overline{E}}{\partial T}\right)_{V,N} = \frac{1}{kT^2}\sigma_E^2 = \frac{1}{kT^2}\left(\overline{E^2} - (\overline{E})^2\right)$$

Derive a similar relation for $\chi = \frac{\partial \overline{\mu_z}}{\partial B}$ for the model of a more general paramagnet. Let us generalize the two-state paramagnet to a p-state paramagnet:

Each spin can be in state $s = 1, 2, 3, \ldots, p$. For a spin in state s the magnetic moment is $\mu_z = \mu_z(s)$ and the energy is $E(s) = -\mu_z B = -\mu_z(s)B$.